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THE LIFE-HISTORY AND CONTROL OF SOME MALAYAN INSECTS OF ECONOMIC IMPORTANCE.

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The three papers which follow deal with the life-history and control of (1) Orgyia turbata *Butler, a small brownish moth, the caterpillars of which have been known to migrate from cover-crops to rubber (2)* Aspidomorpha miliaris *Fabricius, a black-spotted, yellowish tortoise beetle which is a well-known pest of the sweet potato and (3)* Necrobia rufipes *De Geer, a small bluish beetle which is a cosmopolitan pest of copra and other stored products and foodstuffs.*

In the first paper some general observations on the migration of insects from cover and other crops to rubber and coconuts are included, and it is suggested that, from an entomological viewpoint, the cultivation of certain cover-crops may be a dangerous practice. The possibility of Orgyia turbata *becoming adapted to a regular life on rubber is emphasised. The life-history and early stages are described, the life-cycle being completed in about one month. The female moth is wingless, the natural spread of the species being therefore limited to the migrations of the caterpillars. The control measures are based on this fact, and consist mainly of confining the caterpillars to the attacked area of cover-crops by means of a poisoned barrier of lead arsenate, the eggs, caterpillars and female moths within the affected area being collected and destroyed.*

The second paper deals with Aspidomorpha miliaris. *This beetle has not attained pest proportions on the sweet potato in the Malay Peninsula, but is known to do serious*

damage to morning glory, a closely-allied ornamental plant. The life-cycle is completed in about forty days. The species is generally effectively controlled by handpicking, but in severe outbreaks spraying with lead arsenate would be necessary.

Necrobia rufipes, *the subject of the third paper, is not only a serious pest of copra, but in Singapore in 1922 caused so much annoyance to people living in the vicinity of a copra godown, that the Company concerned was instructed to abate the nuisance. The paper on this beetle should therefore interest those engaged in the copra industry. Control measures consist in fumigating with hydrocyanic acid gas or carbon bisulphide, chemical analyses proving that fumigation with the former gas does not affect the commercial or edible value of the copra.*

The writers are indebted to Inche Mahomed Yusope, Junior Agricultural Assistant, for keeping the breeding records incorporated in these papers.

I.—*ORGYIA TURBATA* BUTLER, A POSSIBLE PEST OF RUBBER.

The Lymantriid moth, *Orgyia turbata* Butler, was one of the insects discussed by the senior author in a lecture on the "Interrelation of Insects on Cover and Other Crops to Rubber and Coconuts" at the Annual Conference of the Incorporated Society of Planters in 1926. In the course of the lecture, several instances of insects migrating from cover-crops to rubber and coconut were given and, from an entomological viewpoint, it was suggested that the cultivation of certain cover-crops should not be encouraged.

It might be interesting to consider some of these cases here. P.B. Richards (1918) records that a swarm of caterpillars (*Spodoptera* sp.) at Kuala Selangor devoured at first all the available grass and weeds and then attacked young rubber plants, stripping the leaves and eating the young green bark over several acres.

Another example is provided by the Noctuid moth, *Tiracola plagiata* Walk., a major pest of castor in Malaya. An outbreak of caterpillars of this species occurred on castor in 1923, causing considerable damage to the crop, from which they spread to rubber plants of about one and a half years of age. So serious was the damage that throughout the area practically all the rubber trees were defoliated. The caterpillars of *T. plagiata* would seem to be particu-

larly possessed with the migratory instinct, for on other occasions they have also damaged rubber. The interesting point about their migrations is the fact that they generally seem to leave areas with an abundance of food, to wander to cultivated areas where foodplants are comparatively scarce. Three instances of this peculiar habit may be mentioned. An area of recently budded rubber was severely attacked and much work had to be done before the caterpillars were controlled. The line of migration was from neighbouring "blukar" (secondary growth) with an intervening area of barren soil, before the young rubber seedlings could be reached. On two other occasions, the *Tiracola* caterpillars left the comparative security of "blukar" to attack areas of tapioca and sisal hemp.

Mimosa is one of the most important plants concerned in harbouring certain insects which damage rubber and coconuts, the short-horned grasshopper, *Valanga nigricornis* Burm., being particularly partial to *Mimosa invisa*. In 1923 advice was sought to control this insect. The Estate in question was visited by the senior author; it was found to be planted with coconuts, and though several different cover crops were growing, *V. nigricornis* was entirely confined to the cover crop, Mimosa. The coconuts, which were about one year old, were very badly attacked, and a certain percentage was killed. The cover crop was removed, resulting in the disappearance of the grasshoppers and the eventual recovery of damaged coconuts. This grasshopper is generally prevalent wherever *Mimosa invisa* grows, and another cover crop, if it can be established, should undoubtedly be cultivated.

The subject of this paper, *Orgyia turbata*, is another insect showing a preference for Mimosa, in this case *M. pudica*, and also *Centrosema Plumieri*. Mr. F. R. Mason reported that in a recent outbreak in Province Wellesley, the first instar larvae were practically confined to *M. pudica*.

The first recorded outbreak of *Orgyia turbata* in Malaya was on an Estate near Kuala Lumpur at the beginning of 1926. The caterpillars originated on "blukar" bordering the Estate at a certain point, spreading from there to *Centrosema Plumieri*, which they ate over a very large area of the Estate, also attacking the leaves of rubber to some extent. It was at this stage that advice was sought. As the migration of this moth was entirely dependent on the caterpillars (the females being wingless) the control measures consisted in spraying a poison-barrier, for a depth of about three yards beyond the limit of the last advance of the larva, and collecting all the stages inside the already attacked area. These measures were found to be distinctly successful, as

may be seen from the following letter received from the Manager of the Estate in question:

.....ESTATE,
16th March, 1926.

The Government Entomologist, S.S. & F.M.S.,
Kuala Lumpur.

DEAR SIR,

In reply to your letter No. 2 in Ent. 37/26 dated 8th March, I am pleased to be able to inform you that the recommendations made by you for the control of the caterpillars of the *Orgyia* species of moth on *Centrosema Plumieri* have been attended with great success, and the pest is now to all intents and purposes at an end.

Will you please accept my best thanks for your able assistance and advice in this matter.

I am,
Yours faithfully,

.....
Manager.

In this outbreak *Orgyia turbata* confined itself entirely to the cover crop Centrosema, Passion-flower and Calopogonium being untouched.

The second outbreak was reported this year by Mr. F. R. Mason, Agricultural Field Officer, Province Wellesley and Penang, who found the caterpillars swarming on young rubber seedlings in a clearing of about 260 acres, on an Estate in Province Wellesley. They had apparently spread from the weeds surrounding the area. In a later report he stated that the larvae were practically polyphagous, feeding on Mimosa, Crotolaria, Melastoma and other plants. Subsequently, Mr. Mason reported that the damage done in one section of the Estate would necessitate replanting.

It should be mentioned in connection with the migrations of insects from cover-crops to rubber and coconuts that they *may* become adapted to the latter plants. In Bouvier's book "The Psychic Life of Insects" (1924), two remarkable instances, among others, are given, which emphasise the possibility of adaptation to a different foodplant. He writes as follows:—

"An experiment by Paul Marchal (1908) led to definite results of even more importance. This distinguished biologist induced a scale insect of the peach (*Lecanium corni*) to live on the honey-locust, or false acacia. This was not done without trouble, and only certain larvae issuing from the laying of the *Lecanium* were able to adapt themselves to the new food; but with these there was complete success, beyond all expectation. Becoming adult the following year, the scale insects reproduced upon the locust, and their young had so entirely accepted this host plant that it was impossible to rear to sexual maturity those which he transplanted to the original host (peach). Very quickly the new habit became hereditary and hereditary to the point where the insect could not return to its primitive habit."

In describing another example he says:—

"Still more astonishing is the hereditary transformation of habits obtained by Arnold Pictet in 1911 with *Lasiocampa quercus*. The caterpillars of this moth attack deciduous trees and bushes, notably the oak, and eat the leaves at their edges. When placed upon pine they try to feed, but their mandibles cannot open widely enough. Many die, but certain individuals succeed in existing by attacking the ends of the pine needles, where they dig into the parenchyma. In the second generation the caterpillars had become adapted to the new diet, but they were adapted beyond return, for they perished when placed upon a tree with flat leaves, or they attacked the leaves at the tip and hollowed out the interior as the caterpillars of the preceding generation had learned to do in the pine needles."

It is noteworthy that the two recorded outbreaks of *Orgyia turbata* occurred on seedling and young rubber plants, from which the various stages of this insect were easily collected and destroyed. The proposition might have been different if the caterpillars had migrated to mature trees, for in such cases the control would have presented greater difficulties. It is possible also that the caterpillars might have become more definitely associated with older trees.

Systematic Position and Distribution.

Orgyia turbata (Lepidoptera—Heterocera; Family Lymantriidae) was originally described by Butler in 1879 from specimens collected in the Karen hills, Burma. It is also discussed by Hampson (1892) and Strand (1915). The species is now known from the Karen hills; Province Wellesley; near Kuala Lumpur, Selangor; and Malacca. It is probably widely distributed throughout Malaya. An allied species, *Orgyia postica* Walk., has been recorded in the Peninsula from castor, and in Java from tea, coffee, dadap, rubber and castor. In India and Ceylon, it is known on castor, dadap and rubber.

The Egg.

The eggs are laid in a mass, one layer deep, upon the cocoon from which the female has emerged. Each mass generally contains from 250—300 eggs, but masses have been counted containing as many as 450 eggs. They are laid in regular rows, each egg being covered with short yellowish coloured hairs. Each egg is about .75 mm. in diameter, reticulated, the top slightly flattened and depressed. The centre of the depression is greenish-yellow in colour.

General Description of the Larva.

The caterpillar of *Orgyia turbata* is blackish in colour, with long branched hairs arising from various parts of the body, especially the sides. Just behind the head there are two tubercles, which are usually red at the base, except in the last instar, from which pencils of long black hairs arise. The thoracic segments are marked with white. The first four

segments of the abdomen bear tufts of hairs, which in the male caterpillar are generally yellow in colour, though the first two tufts are often black during the fourth instar of the female larva. The fifth and sixth abdominal segments have white markings in the middle in the early stages, and broad white lines near the sides in the later stages. The sixth and seventh segments have red tubercles in the middle, which are known as eversible glands. Most caterpillars conform to this general description, except for differences in size and slight variation in colour. For more detailed observations on the colouration of the various instars, the first paragraph in the technical descriptions should be consulted.

The Larva.

First Instar.

Head shining black; thoracic segments pale testaceous white; abdominal segments one to four and seven and eight more or less dark brown, considerably darker (almost black) at the bases of the hair tufts; abdominal segments five and six pale testaceous white, fifth with a distinct mid-dorsal pure white area, sixth brownish mid-dorsally; anal segment yellowish. Mouth parts pale yellow. Legs greyish. Seen by reflected light the thoracic segments and abdominal segments five and six of freshly killed or living larvae have a distinct orange tinge due to the deep orange colour of the alimentary canal.

Head somewhat broader than long, deeply notched posteriorly, the limits of the sclerites very faintly marked, the margins with a number of fine setae not very closely set together. First thoracic segment with a conspicuous lateral elevation on each side, orange coloured at base, black at apex, which carries numerous long, closely set, feathery hairs and some shorter setae; in the middle of the segment there are two closely set verrucae carrying similar but shorter hairs. The remaining thoracic segments and abdominal segments one to six have a row of four verrucae, one on each side and two mid-dorsally from which bunches of setae arise, the lateral tubercles bearing as well a long feathery hair; the tubercles on abdominal segments seven and eight are similar, but in seven the lateral feathery hair is about one-third the length of the others; while in eight the lateral tubercles carry a pair of long feathery hairs, instead of one as in the other segments, and the mid-dorsal tubercles also carry a number of long feathery hairs projecting posteriorly; the ninth abdominal segment is short and projects over the tenth (which carries the last pair of prolegs and has only a few fine short hairs) with a series of posteriorly directed long feathery hairs along the posterior margin. The anal end of the larva therefore has the appearance of having a thick bunch of long backwardly directed hairs. The prolegs are on abdominal segments three to six and ten; like the true legs they are finely hairy. The eversible glands are not discernible.

Length: about 2 mm. Just before the first moult the larva grows to about 4 mm., and the colouration becomes more conspicuous.

The newly-hatched larva is pale yellowish-white in colour, abdominal segments one to four and seven to nine greyish-brown above. Head and legs greyish-brown. Eversible glands not visible. In other respects similar to older first instar larvae.

Second Instar.

Head greyish-black, frons paler; mouth parts yellowish, mandibles tinged with brown, entirely brown at apex. First thoracic seg-

ment orange laterally, the antero-lateral processes orange, black at apex, with a grey-black patch in the middle occupying the anterior two-thirds, the posterior third behind this patch yellowish-white; second and third segments, including lateral papillae, mostly white with irregular grey-black markings. First two abdominal segments entirely brownish-black; third and fourth similarly coloured but with a median yellow star-shaped marking, broader than long, with a distinct black spot near each lateral point of the star; fifth and sixth segments mostly dirty yellowish-white, fifth suffused with black laterally, but with a distinct pure white patch in the middle, as in the first instar, sixth blackish in the middle; seventh and eighth brownish-black, seventh with a yellow spot mid-dorsally, which is really a developing eversible gland; ninth mostly orange-yellow; tenth clear white, suffused with grey laterally and at the bases of the anal pro-legs. Ventral surface mostly testaceous, except abdominal segments one and two, which are coloured as on the dorsal surface.

Head a little broader than long, slightly emarginate anteriorly, transverse posteriorly, the sclerites more clearly defined. First thoracic segment longer and broader than any of the others, transverse anteriorly and posteriorly, rounded laterally, the lateral elevations developed into distinct antero-lateral processes carrying a bunch of long acicular pinnate hairs, mixed with shorter pinnate hairs in which the apical areas are very conspicuously feathery, arising from verrucae on the ventral sides; on the anterior margin of the first segment four bunches of comparatively short setose hairs arise, the two median bunches being longer and thicker than the lateral ones, in which only about three setae are present. The dorsal chaetotaxy of the remaining segment is very similar to that of the first instar, but the lateral hairs on the second thoracic segment are short; the mid-dorsal tubercles are now situated more laterally and far apart from each other, almost above the lateral tubercles, and their hairs are longer, pinnate and laterally directed; short pinnate hairs also arise from ventro-lateral projections on the segments, the projections being most conspicuous on the abdominal segments. The anal segment is transverse posteriorly.

Length: about 6 mm.

About the third day the second instar larva grows to 7 mm. or a little more and an erect tuft of short feathery black hairs is distinctly visible on the first and second abdominal segments mid-dorsally, and on the eighth segment. A somewhat similar tuft of hairs, but white in colour, arises from the third abdominal segment. The yellowish spots on segments six and seven are now developed into distinct orange-coloured eversible glands. The chaetotaxy is more marked. The sub-lateral verrucae are clearly defined and a sparse tuft of hairs on each segment on each side of the mid-dorsal line is clearly discernible. A ventro-lateral series of verrucae are now very distinct. On the eighth segment the two long hairs mentioned in the description of the first instar are now seen to arise from the sub-lateral and lateral projections respectively. The first four abdominal segments are now almost entirely black, the markings on three and four ill-defined; the median white patch on five and the black patch on six are very distinct. Just before moulting the larva increases slightly in size, the antero-lateral processes being even more conspicuous. Thoracic segments marked with white medially. Abdominal segments blacker in colour, the bases of all the hair tufts surrounded by a deep velvety black area, except on the white patch on the fifth segment. This white patch is very marked and extends on to the sixth segment sub-laterally as two well-defined stripes; the median area of the sixth segment remains black. The third and fourth segments have an indefinite whitish median area. Abdominal legs and bases of the lateral abdominal verrucae conspicuously erythraeous.

Third Instar.

Little need be said about the third instar. In structure and appearance it is very like mature second instar caterpillars, but is considerably larger (about 9 mm.) and the colour of the body is an intense velvety black above, grey below. The thoracic segments are distinctly transversely striped with white, and the white patches on abdominal segments three and four are better developed with conspicuous tufts of yellowish-white hairs covering them. The tufts on segments one and two are mostly black, and longer than those of three and four. The antero-lateral processes on the first segment are now mostly black with only their bases reddish. Posterior margin of the eighth abdominal segment and anterior margin of ninth whitish. True legs greyish. Abdominal legs conspicuously erythraeous. Structure and chaetotaxy practically identical with that of the second instar, though more marked.

Fourth Instar.

Mostly deep velvety black. First segment with a more or less triangular white median patch, the broad end above; antero-lateral processes entirely black. Second and third segments broadly transversely striped with white. Fifth and sixth abdominal segments with sub-lateral white stripes, the median white patch on the fifth absent. Eversible glands red and conspicuous, especially that on the seventh. Posterior margin of seventh abdominal segment with a narrow transverse, medially interrupted, white stripe.

The chaetotaxy of this instar is fundamentally similar to previous instars though the hairs are more abundant and conspicuous. The antero-lateral processes with a very thick bunch of black hairs, a series arising from the middle of the processes being very closely set together, longer than the others, about half as long as the body, and closely feathered at their apices; these hairs are used as "feelers." The hairs on the anterior margin of the first segment arise from small black pits and extend beyond the apex of the head, they are white in colour. A series of four whitish verrucae are present on the second and third thoracic segments posteriorly on a dorsal whitish ridge; short bunches of white hairs arise from these verrucae. Each of the first four abdominal segments presents a thick dorsal tuft of yellowish-white hairs (in some cases pure white hairs), extending almost to the lateral margins, a median bunch of about ten hairs on the first two abdominal segments have their apices black. The posterior margin of the eighth abdominal segment has a long and thick median tuft of black hairs, conspicuously feathered at their apices, some of the hairs being only half as long as the others. The lateral and sublateral hairs need not be described in detail: they are very long, (mixed, of course, with shorter hairs), abundant, and of a grey colour, the hairs from the lateral projections longer than those from the sub-lateral projections. Prolegs markedly erythraeous: true legs blackish-grey. Length on first moulting about 10 mm., on second day about 12 mm. One larva fed on *Crotolaria* attained a length of 14 mm. on the second day.

Full-grown larvae are not appreciably different from mature fourth instar caterpillars. The first abdominal segment has a very narrow transverse white fascia anteriorly; lateral longitudinal white stripes on four and five broader, slightly curved inwardly; seventh with a lateral white spot on each side anteriorly and a minute white line on each side posteriorly; eighth posteriorly and ninth anteriorly with narrow transverse white fasciae, which together have the appearance of a fairly broad band, the fascia on eight segment medially interrupted; all segments laterally with an ill-defined white line. Lateral areas of the body mottled grey, mostly rich velvety black dorsally, olivaceous-green ventrally. Eversible glands comparatively inconspicuous. Mouth-parts creamy-white, an indefinite dark-red lunate marking above irons. True legs ochraceous brown, middle joint paler. Length 20—24 mm., greatest breadth 3—4 mm.

Sexual Differences in the Larva.

In studying the fourth instar larva, a large number of specimens differed in having the tufts on the first and second abdominal segments entirely black, those on the third and fourth segments being yellowish-white as usual. In these caterpillars, the abdominal tufts were considerably thinner and narrower than usual, and the larger of the two eversible glands was on the sixth, not the seventh, abdominal segment. Moreover, the tuft of black hairs on the eighth abdominal segment posteriorly was only about half as long as in the other larvae, and the caterpillars were also smaller and narrower. These caterpillars were isolated, and bred out in all cases to female moths. A curious fact in the development of the female caterpillar is that after the fourth moult it resembles the male closely both in structure and colour, the first two abdominal tufts assuming the normal colouration of the male caterpillar, and the tuft on the eighth abdominal segment increasing in length. Full-grown female caterpillars may always be distinguished from full-grown male caterpillars by their slightly greater length and more robust appearance (in striking contrast to their appearance during the fourth instar), and by the fact that the tuft on the fourth abdominal segment is usually narrower than in male specimens.

Moulting of the Larva.

For several hours before moulting, the larva remains quiescent, the skin taking on a wrinkled and waxy appearance. The actual casting of the skin takes only a few minutes. The old skin bursts anteriorly and the new instar emerges partly, with the cephalic integument and most of the old skin still attached to it. Through frequent movements, it first casts the old cephalic skin, and the head, white and soft, is observed. The posterior part of the body is violently lashed about and the adhering skin quickly loosened, the larva frequently turning round and tugging at it with its mandibles. The skin is eventually found adhering only to the hairs on the anal segment, and with a final pull with its mandibles, the larva frees itself. The newly-emerged larva does not assume its normal colouration until several hours after hatching.

The Cocoon.

When about to pupate, the larva spins a loose web of fine white silk round itself, strengthened by adhering hairs from its body; this web has numerous large circular openings on the upper surface. The caterpillar is more or less inactive, though it sometimes turns round to spin in another direction. It is shorter and more robust and the markings are very indistinct; the eversible glands and legs lose their red colour. Just before pupating, the larva spins a closely

knit whitish web round itself within the larger web: it thus pupates in a *double* cocoon. The cast skin is left partly within the cocoon.

The Pupa.

The pupa is creamy-white in colour with a distinct greenish tinge; the spiracles are brown, transverse, narrow, and situated on the first six abdominal segments There are considerable differences in the pupa of the two sexes, that of the female being larger and more robust. The female pupa measures about 9 mm. in length by 3 mm. in breadth, and is broadest in the middle, narrowed anteriorly and posteriorly, the posterior third being more or less conical. Anal segment brown with a fairly broad brown spine dorsally. The wing-pads are not ordinarily visible. In many cases, a row of indistinct reddish spots are present on the first five abdominal segments ventrally on each side of the median line. The male pupa measures about 7 mm. in length by 2 mm. in breadth, the sides being more or less parallel on the anterior two-thirds of the body. Anal segment not brown, but the spine present. Wing-pads conspicuous, creamy-white, reaching the posterior margin of the fourth abdominal segment dorso-laterally. Eyes prominent, blackish-brown. Pubescence on dorsal surface more marked than in the female.

The Imago.

Male.—Body black, with grey-brown hairs; antennae grey-brown. Wings brownish, forewings with a warmer tint than the hind wings, which are unicolorous. Forewings with indistinct dark, undulate, subbasal, antemedian, postmedian and marginal longitudinal lines approaching each other towards the posterior margin, a dark spot at the end of the cell, two large orange spots towards the humerus, and one on the apical and anal angles respectively. Underside greyish-brown, darker on the upper half of the forewings. Expanse 24 mm.

Female.—Wings, as in other species of the genus, reduced to minute pads; pale green in colour, almost entirely covered with a dense snow-white pubescence, the ground colour showing through at the margins of the segments, especially ventrally, giving the insect the appearance of having transverse green bands; pubescence not so marked on the head. Broadest across thorax, gradually narrowed posteriorly. Legs and mouth parts pale ochraceous brown. Length usually about 11 mm., but varying according to amount of abdominal distension.

Habits.

Mr. F. R. Mason, Agricultural Field Officer, Province Wellesley and Penang, kindly permits the following field-notes made by himself to be published:—

"The presence of these caterpillars was originally reported to me on February 15th, 1927; they had then been active for about a month. The caterpillars were first observed on an area which had been under coconut cultivation for some years; this area had been felled and weeds and grasses allowed to grow as a cover. In the meantime strips had been cleared 30 feet apart and rubber planted (from seed). At the time of the outbreak the rubber seedlings were about 3 months old. The area on which the pest was first observed had recently been flooded by the breaking of the Muda river Bund.

The chief food of the caterpillars appeared to be the common Dwarf Mimosa—*Mimosa pudica.* On all areas attacked by this pest

the Mimosa had been practically stripped of its leaves. During a number of visits paid to the Estate, the writer did not once find the young instars feeding on anything else but Mimosa. As they grew older and larger they appeared to become less particular in their choice of a food-plant. Half-grown caterpillars were found feeding particularly on the plant known by the Malays as "kedudok" (*Melastoma* sp.). A few half-grown caterpillars were found feeding on the young shoots of the rubber, but not many. When three quarters to full-grown they leave their original food-plant and move away a distance of 8—12 feet to taller and bigger leaved plants, such as "kedudok" and rubber, where they complete growth by feeding until ready to pupate. This habit of migrating to taller trees to pupate is a characteristic of the larvae of *Orgyia turbata*.

The larvae were never once found feeding on grasses. On one occasion only did the writer observe half-grown caterpillars feeding on *Crotolaria* sp.; in this case, however, there was no Mimosa or other suitable food plant in the vicinity.

Even though newly-hatched swarms of the first instar were often found on rubber seedlings, they usually moved off to Mimosa to commence feeding.

The larvae were always found to be most active in the early morning and in the late afternoon"

Observations in the laboratory support and extend Mr. Mason's notes on the food-plants of *Orgyia turbata*. Larvae in the first three instars are very particular in their choice of food, attempts to feed them on rubber (*Hevea brasiliensis*), lalang (*Imperator arundinacea*), ladies' fingers (*Hibiscus esculentus*), "kedudok" (*Melastoma* species) and horsegram (*Dolichos biflorus*) being unsuccessful, though in some cases very slight feeding was observed. Considerable feeding was observed on castor (*Ricinus communis*), while they fed abundantly on *Centrosema* and *Aleurites montana*, skeletonising at first the upper surface of the leaves. The favourite food-plant of the first three instars is the dwarf mimosa (*M. pudica*). Grass was untouched by all instars. As Mr. Mason observes half-grown larvae (i.e. larvae which have passed the third instar) are not so particular in their choice of food-plants, laboratory experiments proving that they will feed on most plants, other than grass, which they previously refused. At present, the caterpillars of *Orgyia turbata* are injurious to rubber when almost full-grown, and then only because of their habit of migrating to taller plants on which to pupate. This migratory habit seems to be the result of a deep-seated instinct, as even in the laboratory, larvae placed in very tall jars climbed up as far as they could go to pupate.

It might be mentioned that caterpillars similar to those of *Orgyia turbata* were received from Serdang in 1924. They were taken in the act of gnawing the female flowers and young nuts of the oil-palm, and in the laboratory were observed to penetrate flowers. No further evidence, however, has been accumulated on this question. An interesting habit of the larva is that it can roll itself up into a ball when disturbed. It is also capable of letting itself down by a silken thread and drawing itself up again by the same means.

Parasites.

Orgyia turbata is parasitised by an unidentified Pteromalid egg-parasite. In one lot of 510 eggs sent in by Mr. Mason, 325 were parasitised, 184 eggs hatching out. The remaining egg was parasitised by a larger Chalcid, which also has not been identified. An unidentified Braconid was reared from a pupa in May, 1927, and two Tachinids were bred out from full-grown larvae which were about to pupate. The caterpillars are also subject to considerable bacterial infection, all the specimens received in the first few consignments dying in the third instar of what appeared to be a bacterial disease. These specimens were fed mostly on *Crotolaria incana* and *Aleurites montana*. Later consignments fed on *Centrosema* and *Mimosa* reached maturity free from bacterial infection.

Life-History.

The table of the life-cycle of the first generation of *Orgyia turbata* provides many interesting features. The egg-period in all cases is 4 days. The duration of the first instar is generally 3-4 days, one male taking 6 days to moult; that of the second instar is 2-4 days, generally 3 days, but one female took 6 days and one male 5 days to moult, that of the third instar is also 2-4 days, an exceptional male taking 5 days; that of the fourth instar is 3-5 days, two males taking only 2 days to moult, while two females remained in the fourth instar for 7 and 9 days respectively; that of the fifth instar is also 3-5 days, generally 4, one male and two females taking 6 days to moult, in marked contrast to a female which only took 2 days; that of the sixth instar varies between 3 and 9 days, only three out of the thirteen examples which moulted a fifth time being males; the seventh instar is restricted to five female caterpillars out of forty-six caterpillars of both sexes and occupies thout 4-5 days. The prepupal period, which is not noted in the table, generally occupies a day. In the pupal stage there is a distinct difference in the two sexes in the number of days before the adult emerges, the males taking from 5-10 days, generally 6-7 days, the females 2-6 days, usually 3 days.

It will thus be seen that not only the duration, but the number of moults, is extremely variable. One male pupated after only two moults, others after three, four or five moults while the females usually pupate after four to six moults, the two cases of females pupating after the third moult being unusual. In almost every case the female has at least one moult more than the male, those specimens which moulted only four times being bred from the same batch of eggs and fed on the same food-plant as the males which pupated after the third moult. The life-cycle for both sexes is completed in less than one month, the female taking a few days longer than the male.

LIFE-CYCLE OF *ORGYIA TURBATA* BUTLER.

First Generation.

(Based on Records from the Entomological Laboratory in 1927.)

Note :— Except for numbers 22, 24, 27, 28, & 29, the total period of the life-cycle has been estimated by adding 4 days for the incubation period, and 4 days for the first instar when the latter addition has been necessary. M = Male. F = Female.

No.	Sex.	Egg Laid.	Egg Hatched.	Incubation Period.	Date of first moult.	Period of first instar in days.	Date of second moult.	Period of second instar in days.	Date of third moult.	Period of third instar in days.	Date of fourth moult.	Period of fourth instar in days.	Date of fifth moult.	Period of fifth instar in days.	Date of sixth moult.	Period of sixth instar in days.	Date of pupation.	Period of last instar in days.	Date of Emergence.	Pupal period in days.	Total period of life-cycle.
1	M	...	...	...	27.6	...	30.6	3	4.7	4	9.7	5	...	...	...	...	13.7	4	19.7	6	30
2	M	...	...	...	28.6	...	1.7	3	6.7	5	10.7	4	...	...	...	...	14.7	4	20.7	6	30
3	M		...	...	28.6	...	30.6	2	4.7	4	8.7	4	12.7	4	...	...	16.7	4	23.7	7	33
4	M	...	...	...	28.6	...	1.7	3	5.7	4	9.7	4	13.7	4	...	...	17.7	4	24.7	7	34
5	M	...	...	...	27.6	...	30.6	3	4.7	4	7.7	3	...	...	...	...	11.7	4	17.7	6	28
6	M	...	..	...	28.6	...	1.7	3	4.7	3	8.7	4	...	...	...	...	11.7	3	18.7	7	28
7	M	..	...	...	27.6	...	30.7	3	4.7	4	8.7	4	...	...	...	...	12.7	4	19.7	7	30
8	M	.	...	...	27.6	...	1.7	4	4.7	3	9.7	5	...	...	...	...	13.7	4	20.7	7	31
9	M	...	...	...	27.6	...	2 7	5	5.7	3	10.7	5	14.7	4	...	...	18.7	4	24.7	6	35
10	M	...	...	...	27.6	...	30.6	3	4.7	4	8.7	4	...	...	...	...	12.7	4	19.7	7	30
11	M	...		...	27.6	...	30.6	3	4.7	4	8.7	4	...	...	...	...	13.7	5	19.7	7	31
12	M	...	23.4	...	27.4	4	29.4	2	1.5	2	...	...	...	...	...	...	5.5	4	11.5	6	22
13	M	.	3.4	...	27.4	4	30.4	3	2.5	2	..	...	...	...	...	...	7.5	5	12.5	5	23
14	M	.	23.4	...	27.4	4	29.4	2	2.5	3	...	...	...	...	...	...	6.5	4	12.5	6	23
15	M	...	23.4	...	27.4	4	29.4	2	2.5	3	...	...	...	...	...	...	6.5	4	12.5	6	23
16	M	...	23.4	...	27.4	4	30.4	3	2.5	2	...	...	...	...	...	...	5.5	3	11.5	6	22
17	M	...	23.4	...	27.4	4	30.4	3	2.5	2	...	...	...	...	...	...	5.5	3	11.5	6	22
18	M	...	23.4	..	27.4	4	30.4	3	2.5	2	..	...	...	...	...	...	7.5	5	17.5	10	28

20	M	...	23.4	..	27.4	4	30.4	3	2.5	2	...	...	...	...	..	...	7.5	5	13.5	6	24
21	M	...	23.4	...	27.4	4	30.4	3	2.5	2	...	...	...	...	...	...	6.5	4	12.5	6	23
22	M	28.4	2.5	4	5.5	3	7.5	2	11.5	4	15.5	...	...	...	...	...	19.5	4	26.5	7	**24**
23	M	...	26.4	...	2.5	6	6.5	4	...	...	...	...	...	...	...	...	10.5	4	16.5	6	24
24	M	2.84	2.5	4	5.5	3	7.5	2	11.5	4	13.5	2	...	...	...	...	19.5	6	26.5	7	**28**
25	M	...	23.4	...	27.4	4	29.4	2	2.5	3	...	...	...	...	...	...	7.5	5	13.5	6	24
26	M	..	25.4	..	28.4	3	2.5	4	5.5	3	...	...	...	...	...	...	8.5	3	15.5	7	24
27	M	28.4	2.5	4	6.5	4	9.5	3	11.5	2	...	...	...	...	...	...	16.5	5	23.5	7	**24**
28	M	28.4	2.5	4	5.5	3	7.5	2	10.5	3	...	...	...	...	...	...	14.5	4	20.5	6	**22**
29	M	28.4	2.5	4	5.5	3	7.5	2	10.5	3	...	...	...	...	...	...	14.5	4	20.5	6	**22**
30	M	...	26.4	..	29.4	3	2.5	3	5.5	3	...	...	...	...	...	...	7.5	2	13.5	6	31
31	F	...	...	...	28.6	...	2.7	4	5.7	3	10.7	3	14.7	4	17.7	3	22.7	5	25.7	3	30
32	F	...	...	...	29.6	...	2.7	3	6.7	4	10.7	4	14.7	4	17.7	3	22.7	5	25.7	3	34
33	F	...	...	...	28.6	...	30.6	2	4.7	4	7.7	3	11.7	4	...	...	20 7	9	23.7	3	33
34	F	...	..	...	27.6	...	30.6	3	4.7	4	8.7	4	13.7	5	17.7	4	21.7	4	24.7	3	35
35	F	...	...	...	28.6	...	1.7	3	4.7	3	7.7	3	13.7	5	...	...	18.7	5	22.7	6	33
36	F	...	...	...	27.6	...	30.6	3	4.7	4	7.7	3	12.7	5	16.7	4	21.7	5	24.7	3	35
37	F	...	...	..	27.6	...	30.6	3	4.7	4	8.7	4	12.7	4	...	...	17.7	5	22.7	5	33
38	F	...	...	...	27.6	...	30.6	3	4.7	4	7.7	3	12.7	5	16.7	4	20.7	4	23.7	3	31
39	F		...	...	27.6	.	1.7	4	4.7	3	11.7	7	17.7	6	...	...	21.7	4	23.7	2	34
40	F	.	...	...	27.6	...	30.6	3	4.7	4	7.7	3	11.7	4	...	...	17.7	6	20.7	3	31
41	F	..	23.4	...	27.4	4	30.4	3	2.5	2	6.5	4	...	...	...	...	9.5	3	12.5	3	23
42	F	...	23.4	...	27.4	4	30.4	3	2.5	2	...	...	...	...	...	...	11.5	9	14.5	3	25
34	F	...	23.4	...	27.4	4	30.4	3	2.5	2	5.5	3	...	...	...	...	8.5	3	12.5	4	23
44	F	...	26.4	...	29.4	3	5.5	6	7.5	2	...	...	...	...	...	...	11.5	4	15.5	4	22
45	F	...	23.4	...	27.4	4	29.4	2	2.5	3	5.5	3	...	...	...	...	11.5	6	14.5	3	25
46	F		23.4	...	27.4	4	29.4	2	2.5	3	5.5	3	...	...	...	...	7.5	2	10.5	3	21

In the laboratory male moths live for an average period of 4—6 days, female moths for 3—9 days.

In natural conditions the life-cycle would probably be completed in a shorter period and with less variation than is the case in the laboratory, where the caterpillars were restricted to a single food-plant, and their peculiar migratory instinct was left unsatisfied.

It is also interesting to consider the relation of the food-plant to the number of moults. Caterpillars numbered 1—2, 12—30, and 41—46 were fed on Crotolaria, 3—11 and 31—40 on Mimosa. The fact that the early instars of *Orgyia turbata* did not thrive on Crotolaria resulted in a heavy mortality, but those which completed their life-cycle did so in a shorter period and with less moults than those fed on Mimosa, the favourite food-plant of the early instars, but from which maturer larvae migrated in nature. It would thus seem that those larvae which survived the early inconveniences caused by feeding on Crotolaria reach maturity sooner than those fed on Mimosa, because Crotolaria was less palatable than Mimosa, a plant on which they fed readily throughout their instars, but which probably caused an accumulation of excess waste matter, the elimination of which necessitated more frequent moults and, in consequence, a more prolonged life-cycle. Conversely, the larvae fed on Crotolaria possibly completed their life-cycle sooner because of the unpalatability of their food, which resulted in slight feeding and therefore a lesser accumulation of waste nitrogenous and carbonaceous matter. In consequence, a smaller number of moults would be required than when healthy feeding is possible. This observation is based on Eisig and Sharp's theory (Sharp, 1901) that ecdyses assist larvae in getting rid of waste nitrogenous and carbonaceous products. Moreover, a quick life-cycle would increase the possibility of the larvae surviving the disadvantages occasioned by unhealthy food. Basing it on the above facts and on general observations by the senior author, the broad hypotheses may be submitted that the life-cycle of many insects will be completed in a shorter time when fed on less palatable substances and not *vice-versa*, as one may be inclined to suppose. This theory, if supported by detailed experimental work, will be of importance in showing that an insect which has once gained a foothold on a plant which is commonly supposed to be unpalatable, may be more numerous than on more favoured food-plants.

It need hardly be mentioned, of course, that this hypotheses is only put forward as an interesting suggestion, and not as a definite conclusion based on detailed studies.

Details of the life-cycle of the second generation of moths which reached maturity in the entomological laboratory were obtained after this paper went to press and are given in the accompanying table. The variability of the larval periods is again evident, and the data otherwise supports that given in the table for the first generation. The female pupal period is again definitely shorter than the male pupal period, but the contrast is not so marked. The extra moult of female caterpillars is well illustrated. The food-plant of all these caterpillars was *Mimosa Pudica*.

LIFE-CYCLE OF *Orgyia turbata* BUTLER.

Second Generation.

Reference Number	I	II	III	IV	V	VI	VII	VIII	IX
Sex	M	M	M	M	M	M	F	F	F
Egg laid ...	21-7-27	21-7-27	21-7-27	27-7-27	27-7-27	27-7-27	27-7-27	27-7-27	27-7-27
Egg hatched ...	26.7	26.7	26.7	1.8	1.8	1.8	1.8	1.8	1.8
Incubation period in days	5	5	5	5	5	5	5	5	5
Date of first moult ..	31.7	30.7	30.7	4.8	4.8	4.8	4.8	4.8	4.8
Period of first instar ...	5	4	4	3	3	3	3	3	3
Date of second moult ...	4.8	3.8	3.8	8.8	9.8	8.8	9.8	8.8	8.8
Period of second instar	4	4	4	4	5	4	5	4	4
Date af third moult ...	11.8	6.8	7.8	10.8	13.8	11.8	11.8	11.8	10.8
Period of third instar ...	7	3	4	2	4	3	2	3	2
Date of fourth moult ...	...	10.8	11.8	14.8	..	14.8	14.8	14.8	14.8
Period of fourth instar..	..	4	4	4	..	3	3	3	4
Date of fifth moult ..	..	..	..	..	..	..	19.8	20.8	17.8
Period of fifth instar ...	..	..	..	..	..	..	5	6	3
Date of cocoon	14.8	13.8	14.8	17.8	17.8	18.8	23.8	24.8	20.8
Period of last instar ...	3	3	3	3	4	4	4	4	3
Date of pupation ..	15.8	14.8	15.8	18.8	18.8	19.8	24.8	25.8	21.8
Cocoon period ...	1	1	1	1	1	1	1	1	1
Date of emergence ...	21.8	21.8	22.8	25.8	25.8	25.8	30.8	31.8	24.8
Pupal period ...	6	7	7	7	7	6	6	6	3
Total period of life-cycle	31	31	32	29	29	29	34	35	28

Control.

As the females of *Orgyia turbata* are wingless, the only means by which the species can spread by itself is limited to the migrations of the caterpillars. Confining the caterpillars to the area occupied by them, by means of a poisoned barrier is, therefore, an economical and efficacious control, where the caterpillars are still confined to cover-crops. The poisoned barrier may be formed by spraying the host-plant with lead arsenate, in the proportion of 2 lbs. to 50 gallons of water, at the limits of the last advance of the caterpillars. Within the attacked area the various stages, especially the eggs and wingless females, should be collected and destroyed. Where the attack is exceptionally serious, the infected area should be sprayed with lead arsenate. From an entomological viewpoint, the cultivation of cover-crops should not be encouraged, and this is supported by a recent statement by Mr. Mason, viz:—"No caterpillars of *Orgyia turbata* can now be found on the Estate in Province Wellesley where I originally discovered them, owing to the fact that the cover-crops have been weeded out".

During an outbreak the rubber trees should be carefully examined for larvae, pupae and adult females. In cases where the caterpillars have not spread to rubber in large numbers handpicking could be effectively employed, but where the attack is serious, spraying with lead arsenate is recommended. To prevent the caterpillars ascending the rubber trees, the trunks may be banded with a rope dipped in a sticky fluid. A useful fluid, which remains effective for about ten days, is made by gently heating sixteen pounds of rosin in one gallon of crude castor oil until the former is completely melted. Thick bands of loose cotton fastened round the trunks of the trees may also be found useful.

Comparision of Orgyia turbata with Orgyia antiqua.

The life history of the Antique or Rusty Tussock Moth (*Orgyia* or *Notolophus antiqua* Linn.), an important pest of fruit trees in Europe and America, has been described by Gentner (1915). This is the only description of a species related to *Orgyia turbata* to which we have access, and a comparison of the two species may therefore be interesting. The broad details of the life-history are very similar, except that *O. antiqua* has a much longer life-history. The female of *O. antiqua* is also wingless, and the larva bears a distinct structural resemblance to *O. turbata*, except for a characteristic pencil of black hairs projecting from each side of the second segment, and two bright orange markings on the fifth segment dorsally. Other points of resemblance are that the larva of *O. antiqua* builds a double cocoon; has the same habit of curling itself up into a ball and suspending itself by a thread when disturbed; the male larva pupates before the female; the female pupal period is much shorter than

that of the male, and the same families of insects parasitise the egg, larva and pupa.

Summary.

The introduction deals with the migration of insects from cover-crops to rubber and coconuts. Attention is drawn to the possible danger of cultivating cover-crops, and to *O. turbata* becoming adapted to life exclusively on rubber.

The life history is discussed, and the various stages described, both technically and popularly; sexual differences in the larva and pupa, habits, and parasitisation are also noted.

It is suggested that increased palatability of the food will result in a longer life-cycle. Further work along these lines may produce interesting and valuable results.

Control measures consist mainly of a barrier of lead arsenate. Hand-picking, and the use of sticky rope or cotton bands round the trees, are also suggested.

Literature.

1879. Butler, Trans. Linn. Soc. (2) I, page 560.

1892. Hampson, Fauna of British India, Moths, I, page 437.

1901. Sharp, Cambridge Natural History, Insects I, p. 163.

1915. Gentner, Second Biennial Crop Pest and Horticultural Report, 1913-1914, Oregon Agricultural College Experiment Station, pages 173-180, Fig. 39 and pl. VIII.

1915. Strand, in Seitz', Macrolepidoptera of the World, Exot. Sect. II, Fauna Indo-Australica, No. 136, page 300, pl. 42h.

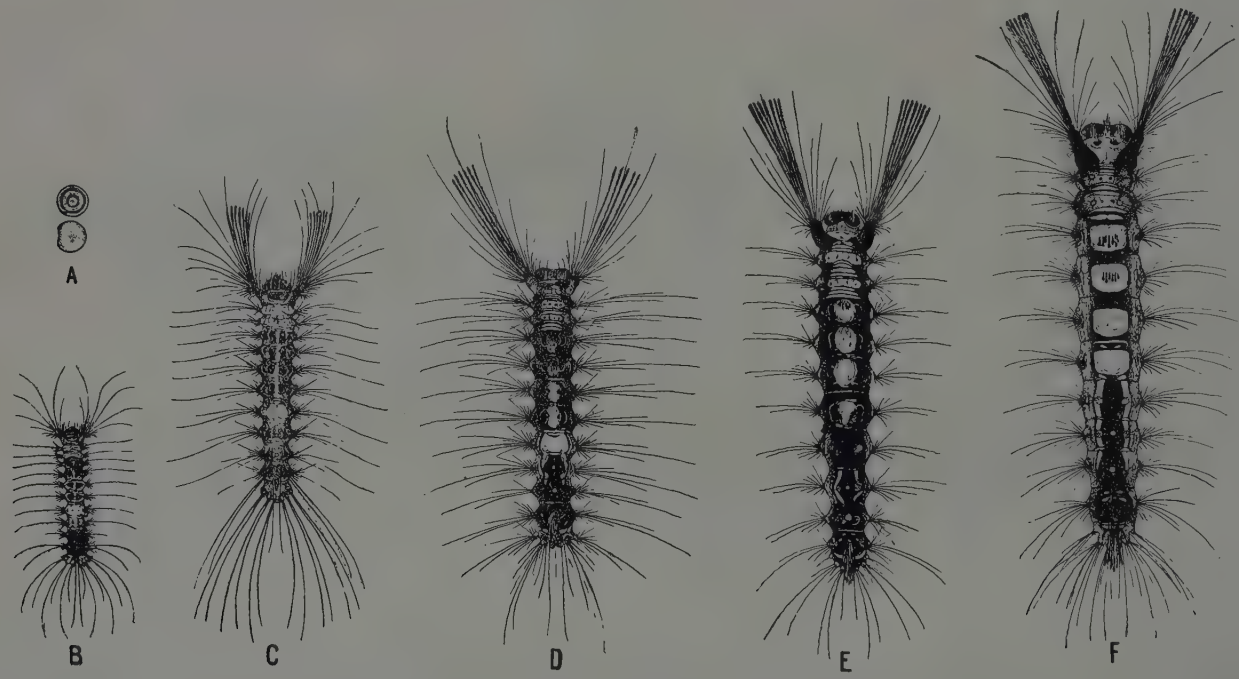
1918. Richards, Agricultural Bulletin, F.M.S., VI, p. 413.

1924. Bouvier, "The Psychic Life of Insects," p. 143-144. The Century Co., New York. (Translation by L. O. Howard).

Explanation of the Figures.

A. Egg.
B. First instar larva.
C. Second instar larva.
D. Third instar larva.
E. Fourth instar larva.
F. Fifth instar larva.
G. Male pupa.
H. Female pupa.
I. Adult female.
J. Adult male.

PLATE I



Egg and Larval Stages of *Orgyia turbata* Butler.

Pupae and Adults of *Orgyia turbata* Butler.

PLATE II

II.—THE TORTOISE BEETLE, *ASPIDOMORPHA MILIARIS* FABR.

The Tortoise Beetle, *Aspidomorpha miliaris* Fabr., is well-known as a pest of the sweet potato (*Ipomoea batatas* Linn.), and has been recorded on this plant in Malaya and India, but a complete account of its life-history and control has not yet been published. The following observations are based largely on records made in the Entomological Laboratory in 1925.

Historical.

This species was first described by Fabricius (1775) under the name *Cassida miliaris*, and was transferred to the genus *Aspidomorpha* by Boheman in 1854. A resumé of the synonymy is given by Maulik (1919, p.334), together with a description and figures of the imagines. A brief description (with figures) of the life-history of *A. miliaris* in the Philippines is given by Schultze (1908, p.264), which was followed a year later by a more general account by Bishop (1909, p.129), who based his observations on material from Singapore. The information given by Schultze and Bishop is summarised by Maulik (1919, p.270). The description and figures of the larval stages given by Schultze and Maulik differ considerably from our description of Malayan material.

Distribution and Food-Plants.

Maulik's account of the distribution of *A. miliaris* (1919, p.336) shows that it is widely distributed in India and Burma, occurring also in Java and Borneo. He does not record it from Ceylon, where it occurs on sweet potato, or from the Philippines and Singapore. We have received it from Butterworth, Province Wellesley, and Port Dickson, Negri Sembilan. The recorded food-plants of *A. miliaris* are *Calonyction bona-nox* Boyer, *Ipomoea triloba* Linn. and *I. pes-caprae* Linn. in the Philippines; *I carnea* Woodrow and *I. superbiens* Ferm. in Singapore; *I. batatas* Linn. in India and Malaya, and *I. purpurea* Roth. at Butterworth and Port Dickson, the only plant on which it is known to do serious damage in the Malay Peninsula. No outbreaks have yet been reported on the sweet potato in Malaya, but it has been most successfully bred in the laboratory on this plant, and probably occurs in certain districts as a minor pest of the sweet potato.

Description of the Beetle.

All the Malayan specimens examined seem to belong to a well-marked variety, which may be described as follows:—

Yellowish—ochraceous, underside a little darker with a black patch on the mesosternum; eyes and apical three joints of the

antennae black; explanate margins of the elytra paler, narrowly black anteriorly along the inner angles and also postero-laterally, with a broad black lateral stripe a little before the anterior margin, extending to about the middle, a triangular black marking on the inner margin on the same plane, which is sometimes contiguous with the oblique stripe, and a black oblique stripe posteriorly, extending from the inner to the outer margins; the raised portion of each elytron with nine black spots distributed as follows: two of equal size on the inner and outer angles respectively of the anterior margin; a spot of the same size a little beyond the middle and adjacent to the inner margin; a median spot, another a little above it at an angle of about 45°, and one below the median spot and adjacent to the outer margin; a very minute spot a little before the middle, close to the inner margin, which is sometimes obsolete; a large semi-lunate spot below the minute one, but more medially situated and a smaller round spot below the semi-lunate spot, near the posterior margin. Length of most specimens about 14 mm.; greatest breadth 12.5 mm.

The different colour varieties described by Schultze (1908) and Maulik (1909), have not yet been found in the Malay Peninsula, all specimens being remarkably constant in colouration, though some smaller specimens (10 mm. x 10 mm.) have the markings greatly reduced. Malayan specimens come nearest to Schultze's figure 6 on plate VI, and the right hand top figure on page 335 of Maulik's work, though differing considerably from both. Bishop's (1909) description and figure (4) corresponds closely with specimens in the entomological collection here. Considering this fact in connection with the well-marked differences in the larval colouration, Malayan individuals appear to represent a distinct variety or subspecies. This is a problem, however, which must be left to a taxonomist with access to Indian and Far Eastern material.

The above colour description and the figures will enable *A. miliaris* to be recognised in Malaya: a full structural description is given by Maulik (1919, p.334).

Description of the Ootheca and Egg.

The egg-case of *A. miliaris* is a complex chitinised structure, varying in size, but averaging about 8 x 3.5 mm. Each ootheca is composed of eight longitudinal chitinous partitions, the four middle compartments containing the eggs (which vary greatly in number), the two lateral compartments being air-chambers. The egg-case is firmly attached to the leaves of the food-plant by a basal squarish layer of chitin. The egg is about 2 mm. long x .5 mm. broad, and is parallel-sided with rounded ends.

Description of the Larva.

Final instar:

Body light ochraceous, lighter along the margin; markings and spines castaneous; spinules transparent white. Head castaneous, except for two pale oblique stripes meeting on the vertex. The dorsal markings are distributed as follows:

A round spot on each side of the mid-dorsal line on the prothoracic segment; two antemedian and two submarginal spots on meso-and metathorax, the two antemedian spots on metathorax larger and more transverse than those on the mesothorax; abdominal segments one to seven with two antemedian and two submarginal, transverse, confluent stripes, giving the segments the appearance of having transverse medially interrupted fasciae; eighth segment with a broad patch on each side of the mid-dorsal line. Stigmata whitish and moderately large.

Thoracic and first abdominal sternites more or less unicolourous, paler than tergites; second abdominal sternite with a lateral angulate marking; abdominal sternites three to seven with two short narrow oblique antemedial lines in the middle of each segment, and two large submarginal markings, broadest in the middle, truncate on the outer, and sharply pointed on the inner, side, on the anterior margin of each segment; fifth and sixth abdominal sternites also with a very narrow line in the middle posteriorly; the bases of all the spines ventro-laterally, except the first and last three, have an indefinite light brownish marking.

The larva bears sixteen spines on each side, the anterior two more closely set together than the others; all the spines of more or less equal length, except five and seven which are shorter, and fourteen to sixteen which are longer, than the others; supra-anal filaments a little longer than these spines. These spines bear a number of spinules on the basal two-thirds, the spinules longest and stoutest towards the base, shortest apically. Spinules on supra-anal filaments very short and delicate. Length, exclusive of spines, 8-9 mm.

The *newly-hatched larva* is of a translucent white colour with the segmentation ill-defined. It bears short lateral branched spines, the spines at the posterior end of the lateral series, considerably longer than the others, the last a little less than twice as long as the one preceding it. The supra-anal filaments are about twice as long as the ventro-anal filaments. Lengh about 1.75 mm.

In the *second instar* the head is brown, the body ochraceous, with the spines better developed and of a brown colour. The two postero-lateral spines are almost of the same length, the last a little longer. Anal filaments also more or less equal in length, though the supra-anal pair are still longer. The first segment has two large brown markings on either side of the mid-dorsal line. Second and third segment with a row of four brown spots, the median spot on third broader than the lateral ones. Abdominal segments one to seven with medially interrupted transverse brown stripes, each stripe being composed of four confluent spots, the inner ones longer than the outer. Length 2—3.5 mm., according to age.

The *third* and *fourth* instars are very similar to the second, except that the chitinisation and markings are more pronounced, the markings and spines in the fourth instar being of a deep castaneous colour. Third instar larvae are about 4—5 mm. in length, fourth instar 6—7 mm.

Comparing Malayan larvae with those described by Schultze (1908, p.264, Pl.111, figs. 2 & 3) and Maulik (1919, p.270, fig. 82), they will be seen to differ very markedly in having the abdominal markings linear and contiguous, not roundish and widely separated, and in the total absence of a median longitudinal row of dark spots. The supra-anal

filaments also appear to be considerably longer, differing from Schultze's and Maulik's figures in this respect. Bishop's figure (2) of a larva from Singapore corresponds to Malayan specimens.

Description of the Pupa.

Nothing can be added to Schultze's description (1908, p.265) of the pupa, which is as follows:—

"Yellowish—ochraceous, two dark spots at the posterior margin of the pronotum and two antemedial spots on each of the first and second abdominal segments. The pronotum of the pupa is about twice as broad as long; marginal area semi-transparent, and with four short, dark brown hooks in front. The spines on the first to the fifth abdominal segment of the larvae are developed in the pupa into flat, semitransparent leaflets prolonged laterally into a black spine. All other spines of the larval stage are absent in the pupal. Stigmata of moderate length."

Life-History.

The life-cycle of five series of specimens is shown in the table: in A, fifty-two grubs were hatched from three oothecae laid on the same day, sixteen of which died in the first and second instars; in B, five grubs hatched from one ootheca, and two from two oothecae, all three oothecae being laid on the same day; in C, seven grubs, of which three died in the final instar, were hatched from a single ootheca; in D and E, sixteen grubs were hatched in each case from one ootheca, fourteen in the D series and eleven in the E series, dying in the second and third instars. It is noteworthy that of the forty-four grubs which reached maturity, there was no variation within their respective series of the period occupied by the different stages of their life-history. The total larval mortality in the five series was fifty per cent. the pupal mortality nil, but these figures are not necessarily representative of the mortality in natural conditions.

A Proctotrypid egg-parasite accounts for a large number of unhatched eggs; this species has not yet been identified. It completes its life-cycle in fourteen days.

The average period of the total life-cycle of *A. miliaris* is about forty-one days, the incubation period occupying an average of 11 days, the first instar 3.00 days, the second instar 3.80 days, the third instar 4.40 days, the fourth instar 3.80 days, the fifth instar 6 days, and the pupal period 8.60 days. These figures are very similar to those of Schultze (1908) and Bishop (1909), except that the number of days given by both these authors for the pupal period is 4-7 as against 6-11.

LIFE-CYCLE OF *ASPIDOMORPHA MILIARIS.*

Ootheca laid.	Hatched.	Incubation period in days.	First moult.	Period of first instar in days.	Second moult.	Period of second instar in days.	Third moult.	Period of third instar in days.	Fourth moult.	Period of fourth instar in days.	Date of pupation.	Period of fifth instar in days.	Date of emergence.	Pupal period in days.	Total period of life-cycle.	Reference No.
20.9.25	1.10.	11	3.10	2	7.10	4	12.10	5	16.10	4	21.10	5	27.10	6	37	A
6.7.25	17.7	11	20.7	3	23.7	3	26.7	3	29.7	3	6.8	8	13.8	7	38	B
20.7.25	31.7	11	3.8	3	6.8	3	11.8	5	15.8	4	20.8	5	31.8	11	42	C
22.7.25	3.8	12	6.8	3	10.8	4	13.8	3	17.8	4	22.8	5	1.9	10	41	D
27.8.25	7.9	11	11.9	4	16.9	5	22.9	6	26.9	4	3.10	7	12.10	9	46	E

The average longevity of adults in the laboratory was three to four months; some specimens, however, lived for ten months. A male and female kept under observation in the same cage lived for 99 days and 114 days respectively, the female laying 34 oothecae in that period. As on the average ten grubs hatch out from an ootheca (the individual figures, of course, being very variable), a single female may be responsible for 350 grubs, of which at least half will reach maturity. It can easily be seen, therefore, how serious *A. miliaris* would be if it attained pest proportions on the sweet potato in Malaya.

Control.

Spraying with lead arsenate is generally employed for the control of Cassid beetles on Convolvulaceae. At Port Dickson, where Morning Glory was seriously attacked, lead arsenate, in the proportion of 2 lbs. to 50 gallons of water, was used with marked success. Handpicking and destroying the various stages of the insect will be found efficacious in areas where the plants are not seriously attacked, and conditions do not warrant the expense of an arsenical spray.

Summary

Aspidomorpha miliaris Fabr. is not uncommon on certain Convolvulaceae in Malaya, and may become an important pest of the sweet potato.

The adults appear to belong to a definite variety of the species, and the larvae differ in many particulars from previous descriptions. It is suggested, therefore, that a detailed taxonomic study of both adults and larvae of *A. miliaris* throughout its geographical range will result in the discovery of well-marked geographical races.

The life-cycle occupies an average period of forty days. A single female may be responsible for 350 larvae, of which at least half will reach maturity—a significant factor in considering the probable seriousness of this insect.

Spraying with lead arsenate is a successful control.

Literature.

1908 Schultze, Philippine Journ. Sci., A, III, pp. 264—265, Pl. II, III, figs. 1—4, IV, figs. 6—10.

1909 Bishop, Journ. Str. Br. Roy. As. Society, No. 53, pp. 129—137, figs. 1—4 (coloured).

1919 Maulik, Faun. Brit. Ind., Chrysomelidae (Hispinae and Cassidinae), pp. 270—273, figs. 82—84, and pp. 334—336, figs. 103 and 104.

Explanation of the Figures.

A. Normal imago of *A. miliaris.*

B. Imago with reduced markings.

C. Transverse section of ootheca, showing arrangement of eggs.

D. Newly-hatched larva. The head is shown in this figure, thus making it look very different from other published figures.

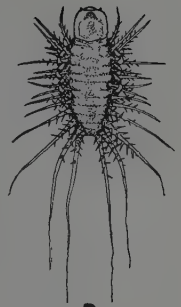
E. Full grown larva.

F. Pupa (after Maulik.)

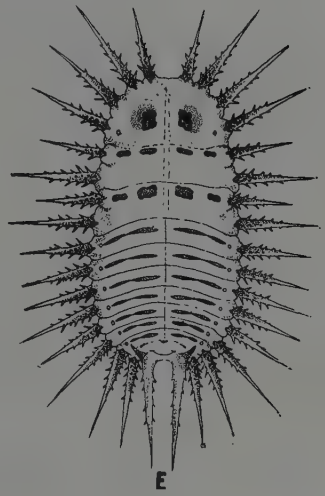
PLATE III

Adults of *Aspidomorpha miliaris* Fabricius.

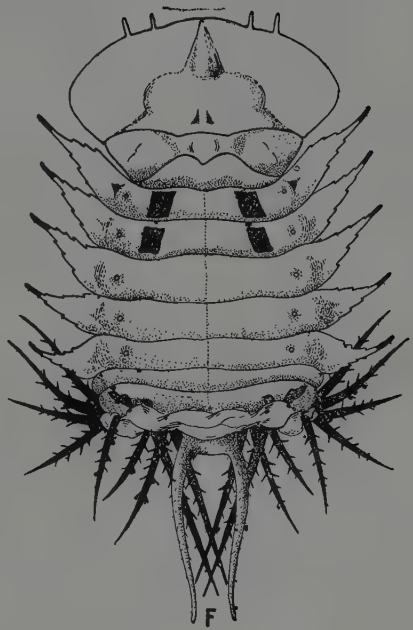
C



D



E



F

Early Stages of *Aspidomorpha miliaris* Fabricius.

PLATE IV

III.—THE COPRA BUG, *NECROBIA RUFIPES* DE GEER.

About five years ago a Company in Singapore wrote to the Agricultural Department for assistance in eradicating certain beetles which infested their copra godowns, from whence they spread to private houses in the vicinity, thus causing considerable annoyance. Indeed, so troublesome was this insect that the Municipal Commissioners passed the following resolution.—

"That the state of things at the Company's godown where copra bugs are produced in enormous quantities and hence infest the neighbouring houses constitutes a nuisance of a public nature and that notice be given to the occupiers that unless the same be abated within one month from this date the Commissioners will consider the advisability of proceeding at law for the abatement thereof under Section 237 of Ordinance No. 135 (Municipal)".

As the immediate control of these beetles was therefore necessary, the Company's godowns were visited and various boats, which carried a cargo of copra, were also inspected in Singapore Harbour. Beetles were found in large numbers in these localities, and proved on examination to be *Necrobia rufipes* De Geer (Order Coleoptera, Family Cleridae), a cosmopolitan pest of copra and other stored products and foodstuffs. As little is known about *Necrobia rufipes* in Malaya, the following notes are offered in the hope that they will prove of interest to those engaged in the copra industry.

Systematic Position.

Necrobia rufipes is the most injurious species of the family Cleridae, the larvae of which are usually predaceous, such as *Callimerus arcufer* Chpn. on the Zygaenid pest, *Artona catoxantha* Hamps. on coconuts. It was originally described by De Geer (1775) as *Clerus rufipes* and was transferred in 1796 to the genus *Necrobia* by Latreille. A list of references and synonymy is given by Schenkling (1910).

Distribution and Popular Names.

This species is very widely distributed, and is known as a common pest of copra in the tropics, though little has been done to control it. It is often a nuisance on ships carrying a cargo of copra, J. B. Corporaal (1922) recording an outbreak on a voyage from the Dutch East Indies to Europe, when the beetles devoured considerable quantities of foodstuffs, even attacking candles. In the Seychelles, it attacks salt fish as well as copra, both of which are stored in close proximity to each other. According to Froggatt (1911), the beetle is known in the Pacific Islands as the "copra bug," the name usually applied to

it in Malaya. In America, it is a serious pest of smoked meats, such as ham and bacon and is, therefore, known as the "red-legged ham beetle" or the "ham beetle", these names being apparently commoner in entomological literature than "copra bug".

The Beetle.

The beetles are of a deep blue colour with a violaceous or greenish lustre, with the legs and first five segments of the antennae brownish; eyes black. They measure about 6 mm. in length and 2.5 mm. in breadth. The females may be distinguished from the males by the fact that each of the elytral punctures gives rise to a stiff black hair, anteriorly inclined, while in the male the hairs are almost recumbent and directed posteriorly. The habits of the adults have not been studied in detail in this country. Like the larvae they are markedly predaceous and are even said to be cannibalistic. They seldom fly, the usual method of progression, being by rapid running. In America, it has been noticed by Simmons and Ellington (1925) that they feign death when roughly handled, and similar observations were made here in 1922.

The Egg.

The eggs of *Necrobia rufipes* are more or less sausage-shaped and of a shining translucent appearance; they measure about 1 mm. x .25 mm. They are laid in groups, records between 20.7.22 and 4.10.22 showing that 23 eggs may be laid in one group, while in a few exceptional cases they were even laid singly. Towards the end of the incubation period, which was four days in all cases, the eggs become more transparent at the extremities, the shape of the embryo being clearly discerned in the middle.

Hatching.

On the point of hatching, the larva stretches itself out, its movements causing the egg at the anal end to be burst open on account of the tubercles on the caudal plate, and the posterior half of the larva is then extended. The anterior half of the larva may remain within the shell for a considerable period, but the larva, by means of its mandibles, eventually tears the shell open about the middle and works its way out. It is probable that the larva whilst inside is feeding upon the egg-shell. In America, Simmons and Ellington (1925) observed that the larva generally tears open both ends of the shell with its mandibles and caudal tubercles respectively, often remaining in the shell, as in a short tunnel, for several hours before leaving it.

The Larva.

The newly hatched larvae are delicate, wrinkled, hairy grubs measuring about 1.25 mm. x .25 mm. and of a more or less uniformly whitish colour. They are quite inactive at the beginning, feeding on unhatched eggs or shells in the vicinity. They are repelled by light and spend most of their time hidden underneath the copra. The full-grown larva measures about 10 mm. x 1.50 mm. The head, upper surface of the first segment and anal segment are more or less ochraceous brown, the rest of the upper surface of the body being white with fine brownish spots and numerous hairs. These larvae are able to crawl actively and to seize and kill such living organisms as they can utilise for food.

The Cocoon.

When fully fed, the larva attaches itself to a dark, dry spot and begins to build a cocoon or pupal cell. The cocoon is built with a white frothy substance, exuded at will from the mouth of the larva, and is usually completed in about 24 hours. During this period the larva lies curled up within the cell.

The Pupa.

Before pupating the larva shrinks considerably in size (*i.e.* to about 6 mm.), so that the body consequently appears to be more robust. The head is fixed at right angles to the axis of the body, and the grub changes to a prepupa, the prepupal period lasting about six days. The pupa measures about 4.25 mm. x 1.50 mm., and is of a more or less greyish white colour with brown eyes. It is covered with short hairs. Pupal movement is restricted to slight wriggling of the abdomen. The adult emerges by gnawing an irregular hole in the pupal case, and usually two days or so elapse before it becomes fully pigmented and capable of flight.

Life-Cycle.

In the accompanying table, details of the life-history of eleven specimens at a temperature between 72.1 and 89.8 (F.) are given. It will be seen that the incubation period occupies 4 days, the larval period between 69 and 97 days (or an average of 81.54 days), the pre-pupal period between 5 and 10 days (or an average of 6.03 days), and the pupal period between 6 and 8 days (or an average of 6.45 days), while the newly emerged imago remains in a depigmented state for one or two days. In captivity imagines lived for approximately two months, though in America they have lived as long as 14 months, a single female sometimes depositing more than 2000 eggs in that period. In America, the larvae were also found to feed on caterpillars of the cheese-skipper

(*Piophila casei* Linn.), sometimes completing their life-cycle in 30 days. The average period of the life-cycle in Malaya, according to the figures below, is 100 days.

DEVELOPMENT OF *Necrobia rufipes* DE GEER IN DAYS.

(*Larvae bred in entomological laboratory on copra*).

No.	Egg period.	Larval period.	Prepupal period.	Pupal period.	Drying period.	Total period of life-cycle.
1	4	77	6	6	1	94
2	4	76	7	6	2	95
3	4	78	7	7	2	98
4	4	75	6	6	2	93
5	4	77	7	6	2	96
6	4	81	5	8	1	99
7	4	93	7	7	1	112
8	4	92	10	7	1	114
9	4	82	6	6	1	99
10	4	97	5	6	1	113
11	4	69	7	6	1	87
Average :	4	81.54	6.63	6.45	1.36	100

CONTROL MEASURES.

This species is controlled in the Philippines (Froggatt, 1911) by fumigation with carbon bisulphide under a tarpaulin, while in the Dutch East Indies (Rutgers, 1918) it is thought sufficient to constantly turn the copra over, which disturbs the beetles and drives them away (a method which would only aggravate conditions in Singapore, as the beetles would probably take refuge in the neighbouring houses), and to separate the copra from young nuts, which is generally less thoroughly cured and, therefore, more liable to attack than copra from old nuts. The best control measure would undoubtedly be to build special fumigation chambers near the customs wharf in each town in which an active trade is carried on in copra (as in Singapore) and to fumigate all incoming copra with hydrocyanic gas. There are numerous difficulties in the way of constructing such a fumigatorium, and thoroughly competent supervision would be essential if copra companies decided to use hydrocyanic gas. The formula for fumigation per hundred cubic feet is as follows:—

Potassium cyanide, 98%	... 1 oz.
Commercial sulphuric acid 1.84 sp. gr.	... 1 ,,
Water	... 3 ,,

The purity of the Potassium cyanide and sulphuric acid to the degree indicated is essential to the success of the fumigation. It was thought that fumigating with hydrocyanic gas may affect the edible and commercial value of the copra. A quantity of copra was, therefore, fumigated for twenty-four hours and then handed over to the Agricultural Chemist (Major B. J. Eaton), who concluded that no ill-effects would result from careful treatment with hydrocyanic gas, provided the copra was thoroughly aired before use. His report is added as an Appendix to this paper.

For many companies it would perhaps be best to cover the copra with a tarpaulin and fumigate with carbon bisulphide, as is done in the Seychelles and Philippines. Commercial grades of carbon bisulphide may be used with success, about 15 lbs. of carbon bisulphide to each 1000 cubic feet of space being sufficient, though the exact quantity for effective destruction of the pest will depend on the amount of egress permitted by the tarpaulin, and will, therefore, have to be determined by experiment. The tarpaulin must be left on the copra, and the godowns closed, for about two days, during which period they must be carefully guarded, as carbon bisulphide is highly inflammable. It is not, however, injurious to the copra, and evaporates quite cleanly without leaving any residue.

It is obvious that great care must be exercised in using these two gases and copra companies who decide to employ fumigation to control *Necrobia rufipes* are recommended to communicate with the Agricultural Department for detailed advice.

Summary.

Necrobia rufipes De Geer, a blue beetle with brownish legs, measuring about 6 mm. long, is widely distributed in the warmer parts of the world as a pest of copra and other stored products, often doing considerable damage.

The larva is whitish with brown spots, and the corneous parts brown; it measures about 10 mm. in length when full-grown.

The average period of the life-cycle appears to be 100 days in Malaya, though it may be considerably less or more. Both larvae and adults are actively predaceous.

Various measures have been suggested for the control of this beetle, the most successful being thorough fumigation in an air-tight chamber with hydrocyanic gas. The following measures are also useful:—

(1) As far as possible thoroughly dried copra should be obtained, as damp and mouldy copra is particularly con-

ducive to the breeding of this insect. It should be remembered that copra from old nuts is less liable to attack than that from young and insufficiently dried nuts.

(2) Where the nature of the locality permits the copra should be constantly turned over to disturb the beetles and drive them away.

(3) Periodic fumigation of the godowns with carbon bisulphide under a tarpaulin would be useful. Normal care must be exercised in its use, and it must be remembered that the gas is very inflammable.

References to Literature.

1775. Geer, C.De. Mémoires pour servir a l' historie des Insects, V, page 165.

1796. Latreille, P.A. Precis des caractères gènériques des insects, disposés dans un naturel, p.35.

1910. Schenkling, S. Coleopterorum Catalogus, part 23, Cleridae, pp.142—143.

1911. Froggatt, W.W. Pests and Diseases of the Coconut Palm. In Dept. of Agric. N.S. Wales, Sci. Bull., 2.

1918. Rutgers, A.A.L. Verslag van den Directeur van Het Algemeen Proefstation der A.V.R.O.S., 1st July, 1917—30th June, 1918. Medan, 1918.

1922. Corporaal, J.B. Ent. Ber. Ned. Ent. Vereen, Amsterdam, VI, No. 126, pp.93—94.

1925. Simmons, P. and Ellington, G.W. The Ham beetle, *Necrobia rufipes* De Geer. In Journal Agricultural Res. Washington, XXX, No. 9, pp.845—863.

This paper is the most important single contribution to the biology of *Necrobia rufipes*, containing a review and list of previous literature, etc.

APPENDIX.

Report on the Presence of Prussic (Hydrocyanic) Acid in Copra after Fumigation with the Gas.

By B. J. Eaton, Agricultural Chemist.

The object of this investigation was to ascertain whether hydrocyanic acid was present in copra after treatment with the gas to destroy *Necrobia rufipes*.

This method of fumigation is one of the most efficient, and is practised in the case of other edible products.

Method of investigation.—It was found that the only test of sufficient delicacy was the Copper Sulphate—Guaiacum test, which detects 1 in 3,000,000.

A standard solution of sodium cyanide was prepared containing 0.035 grammes, equivalent to 0.0160 grammes of prussic acid in 2,000 ccs. of acidified water containing 5.9 ccs. of N/10 sulphuric acid, which was sufficient to liberate the prussic acid.

A series of small filter papers in glass funnels were impregnated with gum guaiacum, dried and then treated with a 0.05 per cent solution of copper sulphate. 50 ccs. of the above standard solution of prussic acid were raised to boiling point and a funnel with filter paper impregnated as above was held for 30 seconds over the vapour from the prussic acid solution. A duplicate test gave similar results. The colouration produced corresponds to 1 part of prussic acid in 125,000. Another portion of the solution was diluted ten times and a standard colouration for 1 in 1,250,000 obtained.

Standards were then prepared for distilled water and untreated copra and were identical.

For the test, 20 grammes of the fumigated copra were taken and boiled with 50 ccs. of water and the test carried out as above with the following results, after comparison with standards.

(1) Copra exposed to the atmosphere for 24 hours after previous fumigation. Prussic acid found: 1 part in 250,000.

(2) Similar copra after exposure to the atmosphere for 48 hours, subsequent to fumigation. Prussic acid found: 1 in 500,000.

(3) Similar copra after exposure to the atmosphere for 48 hours, followed by exposure to the sun for one day and then exposed to the atmosphere for a further three days. Prussic acid found: *Nil.*

Owing to the samples being received at the week-end, it was not possible to ascertain the effect of one day's exposure to sun plus two days' exposure to the atmosphere, which would probably be sufficient to eliminate all the prussic acid.

Conclusions.—The results indicate that, by exposing the copra to the sun and atmosphere as above, the prussic acid is eliminated. After the fumigation period, the copra should be spread in thin layers in the open, provided the weather is dry.

The tests were carried out with the assistance of Mr. J. H. Dennett, Assistant Agricultural Chemist.

Explanation of the Figures.

A. Egg.

B. Young larva.

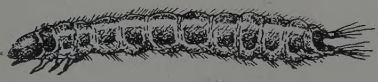
C. Full-grown larva.

D. Pupa (seen from below).

E. Imago.

A

B



C

D

E

Stages in the Life Cycle of *Necrobia rufipes* De Geer.